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# Li-Ion Cell Lot Testing and Flight Screening Results

February 1, 2011

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Prepared for:

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## Abstract

This document reports the lot characterization and sample testing required for certification of a new lot of Moli-Energy Li-Ion ICR-18650H 2200-mAh, 3.75-V cells to be used for a future picosatellite (PicoSat) or CubeSat flight experiment. Results from the required screening of 100% of the flight cells that constitute this new lot are also presented. All testing began upon receipt of the new cell lot in March 2009 and was performed with the primary objective of flight certifying the cells according to NASA standards. The present document supersedes a previous document published in 2009 on a similar subject.[1]

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# 1. Introduction

## 1.1 Purpose

This document reports the lot characterization and sample testing required for certification of a new lot of Moli-Energy Li-Ion ICR-18650H 2200 mAh, 3.75 V cells to be used for a future picosatellite (PicoSat) flight experiment. Results from the required baseline characterization of 100% of the new cell lot are also presented.

All testing began upon receipt of the new cell lot in March 2009 and was performed with the primary objective of flight certifying the cells according to NASA standards.

Similar cells were tested for the pathfinder PSSC Testbed, which achieved orbit in late November 2008; it completed its primary mission and ultimately lasted for about 3 months. Past lot screening results were published in a previous report.[1] The cells tested and presented in this report were manufactured at a different factory than that in the previous report. Otherwise, the cell specifications are identical.

The development of PicoSats and CubeSats at The Aerospace Corporation exists as an innovative, cost-friendly method for testing a constantly growing number of applications in space. Li-Ion cell testing for PicoSats and CubeSats includes basic physical and electrochemical characteristics measurements to ensure that the lot meets screening criteria. Baseline acceptance testing is followed by lot sample tests, designed to test the cell safety mechanisms to ensure that, in the event of power system malfunction, flight hardware surrounding the PicoSat will not be affected. Cell safety specification testing is performed on this lot of Moli-Energy cells to validate previous screening efforts and ensure lot compliance with NASA standards.

## 1.2 Applicable Documents

JSC 23642 Rev D, JSC Fastener Integrity Testing Program

ICD-2-19001, Rev. L, Shuttle Orbiter/Cargo Standard Interfaces (CORE)

MIL-HDBK-5H, Metallic Materials and Elements for Aerospace Vehicle Structures, 12/91

MSFC-HDBK-527F/JSC 09604F, Materials Selection List for Space Hardware Systems.

MSFC-SPEC-522B, Design Criteria for Controlling Stress Corrosion Cracking.

NASA-STD-5003, Fracture Control Requirements for Payloads using the Space Shuttle.

NSTS/ISS 13830, Rev. C, Payload Safety Review and Data Submittal Requirements, May 98

NSTS 1700.7B, Safety Policy and Requirements for Payloads using the STS, 1/89

NSTS 14046, Rev E, Payload Verification Requirements, 3/00

NSTS-21000-IDD-SML, Rev. C, Shuttle Orbiter/Small Payload Accommodation Interfaces, 2/98

NASA-STD-5002, Load Analyses of Spacecraft and Payload

NASA-STD-7001, Payload Vibroacoustic Test Criteria

NASA-STD-7002, Payload Test Requirements

## 2. Cells Procurement

The Aerospace Corporation provided for the procurement of all cells required for flight and lot sample testing. One hundred cells were procured, of which at least 80 were screened for flight, and at least six cells were set aside solely for the purpose of carrying out the flight lot sample/safety mechanism testing. Only fully screened cells will be used for flight.

# 3. Physical and Electrochemical Characteristics

Characterization testing was performed on all (100%) of the lithium-ion cells constituting the lot, including the flight cells. The testing on the lot sample was completed before any testing on the flight cells was performed.

## 3.1 Physical Characteristics

All cells were numbered and labeled. Dimensions and weight of all cells were recorded. Statistical information (average values and standard deviation) on the physical characteristics are shown in Table 1. A visual inspection of the cells was made, and no deformations, cracks, or electrolyte leaks were observed.

Table 1. Moli-Energy Li-Ion Cell Weights

| SN | Weight (g) | SN | Weight (g) | SN | Weight (g) | SN | Weight (g) |
|---|---|---|---|---|---|---|---|
| C001 | 46.014 | C032 | 46.085 | C063 | 46.034 | C094 | 46.033 |
| C002 | 46.147 | C033 | 46.136 | C064 | 46.032 | C095 | 46.048 |
| C003 | 46.058 | C034 | 46.036 | C065 | 46.094 | C096 | 46.031 |
| C004 | 45.985 | C035 | 46.148 | C066 | 45.936 | C097 | 46.030 |
| C005 | 46.027 | C036 | 46.083 | C067 | 46.083 | C098 | 45.955 |
| C006 | 45.985 | C037 | 45.962 | C068 | 46.049 | C099 | 46.199 |
| C007 | 46.097 | C038 | 46.148 | C069 | 45.980 | C100 | 45.903 |
| C008 | 46.052 | C039 | 46.108 | C070 | 45.984 | | |
| C009 | 46.082 | C040 | 46.106 | C071 | 46.097 | **Avg Weight: 46.028 g** | |
| C010 | 45.998 | C041 | 46.040 | C072 | 45.864 | **Std Dev: 0.075 g** | |
| C011 | 46.054 | C042 | 46.051 | C073 | 45.882 | | |
| C012 | 45.975 | C043 | 45.973 | C074 | 45.940 | | |
| C013 | 46.045 | C044 | 45.994 | C075 | 46.079 | | |
| C014 | 46.025 | C045 | 45.860 | C076 | 46.038 | | |
| C015 | 45.976 | C046 | 45.877 | C077 | 45.984 | | |
| C016 | 45.992 | C047 | 46.167 | C078 | 45.961 | | |
| C017 | 46.031 | C048 | 46.048 | C079 | 45.902 | | |
| C018 | 46.027 | C049 | 46.072 | C080 | 46.108 | | |
| C019 | 46.076 | C050 | 46.102 | C081 | 45.987 | | |
| C020 | 46.015 | C051 | 46.038 | C082 | 46.024 | | |
| C021 | 45.860 | C052 | 46.056 | C083 | 45.963 | | |
| C022 | 45.992 | C053 | 45.905 | C084 | 45.879 | | |
| C023 | 46.006 | C054 | 46.200 | C085 | 46.125 | | |
| C024 | 45.984 | C055 | 46.121 | C086 | 46.112 | | |
| C025 | 46.012 | C056 | 46.084 | C087 | 46.058 | | |
| C026 | 46.045 | C057 | 46.057 | C088 | 46.057 | | |
| C027 | 45.983 | C058 | 46.021 | C089 | 46.089 | | |
| C028 | 46.003 | C059 | 45.964 | C090 | 46.053 | | |
| C029 | 46.044 | C060 | 45.962 | C091 | 46.081 | | |
| C030 | 45.843 | C061 | 46.084 | C092 | 46.080 | | |
| C031 | 46.008 | C062 | 46.139 | C093 | 45.979 | | |

## 3.2 Electrochemical Characteristics

The open-circuit voltage (OCV) and closed-circuit voltage (CCV) of the cells was measured and recorded. The OCV of each cell was found to be between 3.6 V and 4.2 V, as specified in the lot acceptance criteria. No further testing was required.

CCV tests were performed with a 2 A current for 30 s. No cell values of CCV below 2.5 V were found.

All cells passed the initial OCV and CCV characterization tests. Results are shown in Table 2.

Table 2. Moli-Energy Li-Ion Cell OCV and CCV Values

| SN | OCV | CCV | SN | OCV | CCV | SN | OCV | CCV | SN | OCV | CCV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C001 | 3.810 | 3.573 | C032 | 3.809 | 3.574 | C063 | 3.807 | 3.581 | C094 | 3.807 | 3.603 |
| C002 | 3.810 | 3.573 | C033 | 3.809 | 3.574 | C064 | 3.806 | 3.585 | C095 | 3.807 | 3.582 |
| C003 | 3.811 | 3.567 | C034 | 3.809 | 3.578 | C065 | 3.809 | 3.584 | C096 | 3.806 | 3.582 |
| C004 | 3.810 | 3.571 | C035 | 3.810 | 3.577 | C066 | 3.806 | 3.583 | C097 | 3.806 | 3.581 |
| C005 | 3.811 | 3.566 | C036 | 3.807 | 3.585 | C067 | 3.807 | 3.584 | C098 | 3.806 | 3.585 |
| C006 | 3.811 | 3.576 | C037 | 3.808 | 3.585 | C068 | 3.806 | 3.582 | C099 | 3.806 | 3.579 |
| C007 | 3.810 | 3.573 | C038 | 3.808 | 3.586 | C069 | 3.806 | 3.586 | C100 | 3.806 | 3.582 |
| C008 | 3.809 | 3.573 | C039 | 3.808 | 3.584 | C070 | 3.806 | 3.582 | | | |
| C009 | 3.810 | 3.571 | C040 | 3.807 | 3.581 | C071 | 3.806 | 3.583 | **Average** | **3.808** | **3.581** |
| C010 | 3.810 | 3.575 | C041 | 3.806 | 3.587 | C072 | 3.806 | 3.586 | **Minimum** | **3.805** | **3.566** |
| C011 | 3.811 | 3.574 | C042 | 3.807 | 3.585 | C073 | 3.807 | 3.584 | | | |
| C012 | 3.810 | 3.576 | C043 | 3.807 | 3.585 | C074 | 3.805 | 3.585 | | | |
| C013 | 3.811 | 3.574 | C044 | 3.808 | 3.582 | C075 | 3.806 | 3.585 | | | |
| C014 | 3.810 | 3.576 | C045 | 3.808 | 3.586 | C076 | 3.806 | 3.585 | | | |
| C015 | 3.809 | 3.574 | C046 | 3.808 | 3.584 | C077 | 3.806 | 3.585 | | | |
| C016 | 3.806 | 3.577 | C047 | 3.809 | 3.583 | C078 | 3.806 | 3.585 | | | |
| C017 | 3.811 | 3.576 | C048 | 3.809 | 3.587 | C079 | 3.806 | 3.585 | | | |
| C018 | 3.811 | 3.575 | C049 | 3.808 | 3.586 | C080 | 3.806 | 3.583 | | | |
| C019 | 3.811 | 3.575 | C050 | 3.806 | 3.581 | C081 | 3.806 | 3.586 | | | |
| C020 | 3.810 | 3.576 | C051 | 3.806 | 3.582 | C082 | 3.807 | 3.583 | | | |
| C021 | 3.810 | 3.578 | C052 | 3.806 | 3.583 | C083 | 3.806 | 3.583 | | | |
| C022 | 3.810 | 3.576 | C053 | 3.806 | 3.585 | C084 | 3.806 | 3.583 | | | |
| C023 | 3.810 | 3.574 | C054 | 3.808 | 3.580 | C085 | 3.806 | 3.584 | | | |
| C024 | 3.809 | 3.576 | C055 | 3.807 | 3.584 | C086 | 3.806 | 3.584 | | | |
| C025 | 3.809 | 3.573 | C056 | 3.806 | 3.584 | C087 | 3.807 | 3.584 | | | |
| C026 | 3.810 | 3.572 | C057 | 3.807 | 3.581 | C088 | 3.806 | 3.585 | | | |
| C027 | 3.809 | 3.571 | C058 | 3.807 | 3.581 | C089 | 3.807 | 3.583 | | | |
| C028 | 3.808 | 3.574 | C059 | 3.808 | 3.584 | C090 | 3.805 | 3.584 | | | |
| C029 | 3.806 | 3.577 | C060 | 3.808 | 3.585 | C091 | 3.807 | 3.584 | | | |
| C030 | 3.810 | 3.575 | C061 | 3.808 | 3.584 | C092 | 3.806 | 3.582 | | | |
| C031 | 3.809 | 3.575 | C062 | 3.806 | 3.586 | C093 | 3.806 | 3.583 | | | |

## 3.3 Charge/Discharge Cycle

All cells underwent two charge/discharge cycles before being subjected to the lot sample or screening tests below. A derating of 10% was used such that the cells were rated at 2.0 Ah. Charging was performed on each cell using a 1 C (2 A) current to 4.2 V, and held at constant voltage until the current fell to 20 mA. Discharge was at 0.5 C (1 A) to a cutoff voltage of 2.5 V. The capacities of the cells

were recorded. All cells were above the derated capacity of 2.0 Ah. Impedance at 3.7 V was determined using a pulse discharge of 2 A for 30 s.

All cells passed the charge/discharge cycling. Results are shown in Table 3.

Table 3. Moli-Energy Li-Ion Cell Charge/Discharge Cycling Characterization

| SN | Capacity (Ah) | Impedance (Ohm) | SN | Capacity (Ah) | Impedance (Ohm) | SN | Capacity (Ah) | Impedance (Ohm) | SN | Capacity (Ah) | Impedance (Ohm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C001 | 2.129 | 0.036 | C032 | 2.145 | 0.042 | C063 | 2.162 | 0.030 | C094 | 2.127 | 0.029 |
| C002 | 2.154 | 0.034 | C033 | 2.158 | 0.032 | C064 | 2.148 | 0.028 | C095 | 2.154 | 0.029 |
| C003 | 2.132 | 0.032 | C034 | 2.126 | 0.031 | C065 | 2.161 | 0.029 | C096 | 2.149 | 0.029 |
| C004 | 2.113 | 0.032 | C035 | 2.148 | 0.031 | C066 | 2.135 | 0.028 | C097 | 2.151 | 0.029 |
| C005 | 2.135 | 0.026 | C036 | 2.166 | 0.028 | C067 | 2.156 | 0.036 | C098 | 2.140 | 0.029 |
| C006 | 2.133 | 0.033 | C037 | 2.142 | 0.028 | C068 | 2.147 | 0.028 | C099 | 2.158 | 0.030 |
| C007 | 2.151 | 0.032 | C038 | 2.163 | 0.028 | C069 | 2.126 | 0.027 | C100 | 2.101 | 0.030 |
| C008 | 2.125 | 0.028 | C039 | 2.149 | 0.028 | C070 | 2.133 | 0.028 | | | |
| C009 | 2.147 | 0.028 | C040 | 2.161 | 0.028 | C071 | 2.168 | 0.029 | **Average** | **2.143** | **0.030** |
| C010 | 2.137 | 0.031 | C041 | 2.134 | 0.028 | C072 | 2.134 | 0.029 | | | |
| C011 | 2.147 | 0.032 | C042 | 2.156 | 0.028 | C073 | 2.109 | 0.029 | | | |
| C012 | 2.130 | 0.031 | C043 | 2.130 | 0.028 | C074 | 2.125 | 0.028 | | | |
| C013 | 2.146 | 0.033 | C044 | 2.139 | 0.027 | C075 | 2.158 | 0.035 | | | |
| C014 | 2.134 | 0.023 | C045 | 2.114 | 0.029 | C076 | 2.148 | 0.027 | | | |
| C015 | 2.126 | 0.028 | C046 | 2.123 | 0.028 | C077 | 2.145 | 0.028 | | | |
| C016 | 2.121 | 0.032 | C047 | 2.186 | 0.029 | C078 | 2.151 | 0.030 | | | |
| C017 | 2.143 | 0.031 | C048 | 2.149 | 0.035 | C079 | 2.153 | 0.028 | | | |
| C018 | 2.139 | 0.032 | C049 | 2.154 | 0.029 | C080 | 2.159 | 0.029 | | | |
| C019 | 2.142 | 0.027 | C050 | 2.165 | 0.031 | C081 | 2.138 | 0.028 | | | |
| C020 | 2.118 | 0.026 | C051 | 2.151 | 0.030 | C082 | 2.161 | 0.029 | | | |
| C021 | 2.102 | 0.031 | C052 | 2.153 | 0.030 | C083 | 2.138 | 0.028 | | | |
| C022 | 2.142 | 0.026 | C053 | 2.132 | 0.029 | C084 | 2.137 | 0.029 | | | |
| C023 | 2.138 | 0.032 | C054 | 2.182 | 0.028 | C085 | 2.169 | 0.028 | | | |
| C024 | 2.117 | 0.032 | C055 | 2.157 | 0.032 | C086 | 2.153 | 0.042 | | | |
| C025 | 2.136 | 0.032 | C056 | 2.151 | 0.028 | C087 | 2.141 | 0.029 | | | |
| C026 | 2.145 | 0.032 | C057 | 2.161 | 0.028 | C088 | 2.158 | 0.028 | | | |
| C027 | 2.138 | 0.032 | C058 | 2.161 | 0.031 | C089 | 2.171 | 0.028 | | | |
| C028 | 2.108 | 0.032 | C059 | 2.143 | 0.030 | C090 | 2.141 | 0.029 | | | |
| C029 | 2.151 | 0.032 | C060 | 2.120 | 0.029 | C091 | 2.158 | 0.028 | | | |
| C030 | 2.116 | 0.032 | C061 | 2.162 | 0.028 | C092 | 2.154 | 0.044 | | | |
| C031 | 2.128 | 0.031 | C062 | 2.164 | 0.029 | C093 | 2.144 | 0.029 | | | |

### 3.4 Vacuum Leak Test

Fully charged cells were weighed to the nearest hundredth of a gram and placed in a vacuum chamber that is capable of holding less than 0.1 psia pressure. The pressure of the chamber was taken down to less than 0.1 psia at the rate of 8 psi/min. The cells were held under this condition for at least 6 h. The chamber was then pressurized to 14 psia at the rate of 9 psi/min. The cells were removed from the chamber and checked for any visual changes, such as cracks, leaks, or venting. They were then placed outside the chamber at ambient temperature for at least 2 h and then weighed again. The difference in the weight of the cells was less than 1%. Results are shown in Table 4.

Table 4. Moli-Energy Li-Ion Cell Weights After Vacuum Leak Test

| SN | Initial Weight (g) | Final Weight (g) | Difference (g) | % Change | SN | Initial Weight (g) | Final Weight (g) | Difference (g) | % Change |
|---|---|---|---|---|---|---|---|---|---|
| C001 | 46.01 | 46.01 | 0.00 | -0.002% | C051 | 46.04 | 46.04 | 0.00 | 0.000% |
| C002 | 46.15 | 46.15 | 0.00 | 0.000% | C052 | 46.06 | 46.06 | 0.00 | 0.000% |
| C003 | 46.06 | 46.06 | 0.00 | 0.000% | C053 | 45.91 | 45.91 | 0.00 | 0.000% |
| C004 | 45.99 | 45.98 | 0.00 | -0.002% | C054 | 46.20 | 46.20 | 0.00 | -0.004% |
| C005 | 46.03 | 46.03 | 0.00 | 0.000% | C055 | 46.12 | 46.12 | 0.00 | 0.000% |
| C006 | 45.99 | 45.99 | 0.00 | 0.000% | C056 | 46.08 | 46.08 | 0.00 | 0.000% |
| C007 | 46.10 | 46.10 | 0.00 | 0.000% | C057 | 46.06 | 46.06 | 0.00 | -0.002% |
| C008 | 46.05 | 46.05 | 0.00 | 0.000% | C058 | 46.02 | 46.02 | 0.00 | -0.002% |
| C009 | 46.08 | 46.08 | 0.00 | -0.002% | C059 | 45.96 | 45.96 | 0.00 | 0.000% |
| C010 | 46.00 | 46.00 | 0.00 | 0.000% | C060 | 45.96 | 45.96 | 0.00 | -0.002% |
| C011 | 46.05 | 46.05 | 0.00 | 0.000% | C061 | 46.08 | 46.08 | 0.00 | 0.000% |
| C012 | 45.98 | 45.86 | 0.12 | -0.252% | C062 | 46.14 | 46.14 | 0.00 | 0.000% |
| C013 | 46.05 | 46.05 | 0.00 | 0.000% | C063 | 46.03 | 46.03 | 0.00 | -0.002% |
| C014 | 46.03 | 46.03 | 0.00 | 0.000% | C064 | 46.03 | 46.03 | 0.00 | -0.005% |
| C015 | 45.98 | 45.98 | 0.00 | 0.000% | C065 | 46.09 | 46.09 | 0.00 | -0.003% |
| C016 | 45.99 | 45.99 | 0.00 | 0.000% | C066 | 45.94 | 45.93 | 0.00 | -0.004% |
| C017 | 46.03 | 46.03 | 0.00 | -0.002% | C067 | 46.08 | 46.08 | 0.00 | -0.002% |
| C018 | 46.03 | 46.03 | 0.00 | -0.002% | C068 | 46.05 | 46.05 | 0.00 | -0.002% |
| C019 | 46.08 | 46.08 | 0.00 | -0.002% | C069 | 45.98 | 45.98 | 0.00 | -0.005% |
| C020 | 46.02 | 46.01 | 0.00 | -0.002% | C070 | 45.98 | 45.98 | 0.00 | -0.002% |
| C021 | 45.86 | 45.97 | 0.11 | 0.249% | C071 | 46.10 | 46.10 | 0.00 | -0.002% |
| C022 | 45.99 | 45.99 | 0.00 | 0.000% | C072 | 45.86 | 45.86 | 0.00 | -0.004% |
| C023 | 46.01 | 46.01 | 0.00 | 0.000% | C073 | 45.88 | 45.88 | 0.00 | -0.004% |
| C024 | 45.98 | 45.98 | 0.00 | -0.004% | C074 | 45.94 | 45.94 | 0.00 | -0.004% |
| C025 | 46.01 | 46.01 | 0.00 | -0.002% | C075 | 46.08 | 46.08 | 0.00 | -0.003% |
| C026 | 46.05 | 46.05 | 0.00 | 0.000% | C076 | 46.04 | 46.04 | 0.00 | -0.004% |
| C027 | 45.98 | 45.98 | 0.00 | -0.004% | C077 | 45.98 | 45.98 | 0.00 | -0.003% |
| C028 | 46.00 | 46.00 | 0.00 | -0.002% | C078 | 45.96 | 45.96 | 0.00 | -0.004% |
| C029 | 46.04 | 46.04 | 0.00 | -0.002% | C079 | 45.90 | 45.90 | 0.00 | -0.003% |
| C030 | 45.84 | 45.84 | 0.00 | 0.000% | C080 | 46.11 | 46.11 | 0.00 | -0.002% |
| C031 | 46.01 | 46.01 | 0.00 | 0.000% | C081 | 45.99 | 45.99 | 0.00 | -0.002% |
| C032 | 46.09 | 46.09 | 0.00 | 0.002% | C082 | 46.02 | 46.02 | 0.00 | -0.003% |
| C033 | 46.14 | 46.14 | 0.00 | 0.000% | C083 | 45.96 | 45.96 | 0.00 | -0.002% |
| C034 | 46.04 | 46.04 | 0.00 | 0.004% | C084 | 45.88 | 45.88 | 0.00 | -0.004% |
| C035 | 46.15 | 46.15 | 0.00 | 0.002% | C085 | 46.13 | 46.12 | 0.00 | -0.001% |
| C036 | 46.08 | 45.97 | 0.11 | -0.237% | C086 | 46.11 | 46.11 | 0.00 | -0.001% |
| C037 | 45.96 | 46.16 | 0.20 | 0.431% | C087 | 46.06 | 46.06 | 0.00 | -0.002% |
| C038 | 46.15 | 46.17 | 0.03 | 0.056% | C088 | 46.06 | 46.06 | 0.00 | -0.002% |
| C039 | 46.11 | 46.03 | 0.08 | -0.169% | C089 | 46.09 | 46.09 | 0.00 | -0.002% |
| C040 | 46.11 | 46.12 | 0.01 | 0.026% | C090 | 46.05 | 46.05 | 0.00 | -0.002% |
| C041 | 46.04 | 46.06 | 0.02 | 0.041% | C091 | 46.08 | 46.08 | 0.00 | -0.004% |
| C042 | 46.05 | 46.06 | 0.01 | 0.026% | C092 | 46.08 | 46.08 | 0.00 | -0.004% |
| C043 | 45.97 | 46.01 | 0.03 | 0.070% | C093 | 45.98 | 45.98 | 0.00 | -0.004% |
| C044 | 45.99 | 46.08 | 0.09 | 0.196% | C094 | 46.03 | 46.03 | 0.00 | -0.005% |
| C045 | 45.86 | 45.87 | 0.01 | 0.028% | C095 | 46.05 | 46.05 | 0.00 | -0.004% |
| C046 | 45.88 | 45.89 | 0.01 | 0.024% | C096 | 46.03 | 46.03 | 0.00 | -0.003% |
| C047 | 46.17 | 45.98 | 0.18 | -0.396% | C097 | 46.03 | 46.03 | 0.00 | -0.004% |
| C048 | 46.05 | 45.97 | 0.07 | -0.161% | C098 | 45.96 | 45.95 | 0.00 | -0.002% |
| C049 | 46.07 | 46.06 | 0.01 | -0.028% | C099 | 46.20 | 46.20 | 0.00 | -0.003% |
| C050 | 46.10 | 46.10 | 0.00 | -0.004% | C100 | 45.90 | 45.90 | 0.00 | -0.003% |
| | | | | | | Initial (g) | Final (g) | | |
| | | | | | Average | 46.03 | 46.03 | | |

One discharge/charge/discharge cycle was carried out on the cells after the vacuum leak test. Capacity values before and after the test are shown in Table 5. All tested cells were within 95% of their initial capacity.

Note: Cells C009 and C023 were misplaced following being weighed after the vacuum leak test and prior to running the capacity check. If they are found, they will not be included as part of the flight cells.

Table 5. Moli-Energy Li-Ion Cell Capacity Check After Vacuum Leak Test

| SN | Capacity BEFORE | Capacity AFTER | % of before | SN | Capacity BEFORE | Capacity AFTER | % of before |
|---|---|---|---|---|---|---|---|
| C001 | 2.129 | 2.148 | 100.9% | C053 | 2.132 | 2.138 | 100.3% |
| C002 | 2.154 | 2.174 | 100.9% | C054 | 2.182 | 2.174 | 99.6% |
| C003 | 2.132 | 2.149 | 100.8% | C055 | 2.157 | 2.155 | 99.9% |
| C004 | 2.113 | 2.143 | 101.4% | C056 | 2.151 | 2.149 | 99.9% |
| C005 | 2.135 | 2.159 | 101.1% | C057 | 2.161 | 2.158 | 99.8% |
| C006 | 2.133 | 2.161 | 101.3% | C058 | 2.161 | 2.162 | 100.0% |
| C007 | 2.151 | 2.170 | 100.9% | C059 | 2.143 | 2.157 | 100.7% |
| C008 | 2.125 | 2.147 | 101.1% | C060 | 2.120 | 2.134 | 100.7% |
| C010 | 2.137 | 2.150 | 100.6% | C061 | 2.162 | 2.160 | 99.9% |
| C011 | 2.147 | 2.101 | 97.9% | C062 | 2.164 | 2.163 | 100.0% |
| C012 | 2.130 | 2.087 | 98.0% | C063 | 2.162 | 2.165 | 100.2% |
| C013 | 2.146 | 2.156 | 100.5% | C064 | 2.148 | 2.148 | 100.0% |
| C014 | 2.134 | 2.092 | 98.0% | C065 | 2.161 | 2.166 | 100.2% |
| C015 | 2.126 | 2.143 | 100.8% | C066 | 2.135 | 2.145 | 100.5% |
| C016 | 2.121 | 2.145 | 101.1% | C067 | 2.156 | 2.152 | 99.8% |
| C017 | 2.143 | 2.157 | 100.6% | C068 | 2.147 | 2.146 | 100.0% |
| C018 | 2.139 | 2.154 | 100.7% | C069 | 2.126 | 2.129 | 100.1% |
| C019 | 2.142 | 2.155 | 100.6% | C070 | 2.133 | 2.137 | 100.2% |
| C020 | 2.118 | 2.154 | 101.7% | C071 | 2.168 | 2.165 | 99.9% |
| C021 | 2.102 | 2.066 | 98.3% | C072 | 2.134 | 2.149 | 100.7% |
| C022 | 2.142 | 2.101 | 98.1% | C073 | 2.109 | 2.135 | 101.2% |
| C024 | 2.117 | 2.140 | 101.1% | C074 | 2.125 | 2.137 | 100.5% |
| C025 | 2.136 | 2.094 | 98.0% | C075 | 2.158 | 2.154 | 99.8% |
| C026 | 2.145 | 2.097 | 97.8% | C076 | 2.148 | 2.157 | 100.4% |
| C027 | 2.138 | 2.159 | 101.0% | C077 | 2.145 | 2.154 | 100.4% |
| C028 | 2.108 | 2.137 | 101.4% | C078 | 2.151 | 2.146 | 99.8% |
| C029 | 2.151 | 2.169 | 100.8% | C079 | 2.153 | 2.164 | 100.5% |
| C030 | 2.116 | 2.147 | 101.5% | C080 | 2.159 | 2.159 | 100.0% |
| C031 | 2.128 | 2.086 | 98.0% | C081 | 2.138 | 2.138 | 100.0% |
| C032 | 2.145 | 2.154 | 100.4% | C082 | 2.161 | 2.158 | 99.8% |
| C033 | 2.158 | 2.168 | 100.5% | C083 | 2.138 | 2.142 | 100.2% |
| C034 | 2.126 | 2.145 | 100.9% | C084 | 2.137 | 2.149 | 100.6% |
| C035 | 2.148 | 2.157 | 100.4% | C085 | 2.169 | 2.169 | 100.0% |
| C036 | 2.166 | 2.161 | 99.7% | C086 | 2.153 | 2.150 | 99.9% |
| C037 | 2.142 | 2.147 | 100.2% | C087 | 2.141 | 2.151 | 100.5% |
| C038 | 2.163 | 2.155 | 99.6% | C088 | 2.158 | 2.158 | 100.0% |
| C039 | 2.149 | 2.145 | 99.8% | C089 | 2.171 | 2.165 | 99.7% |
| C040 | 2.161 | 2.152 | 99.6% | C090 | 2.141 | 2.141 | 100.0% |
| C041 | 2.134 | 2.147 | 100.6% | C091 | 2.158 | 2.156 | 99.9% |
| C042 | 2.156 | 2.149 | 99.7% | C092 | 2.154 | 2.157 | 100.2% |
| C043 | 2.130 | 2.143 | 100.6% | C093 | 2.144 | 2.145 | 100.0% |

| SN | Capacity BEFORE | Capacity AFTER | % of before |
|---|---|---|---|
| C044 | 2.139 | 2.144 | 100.2% |
| C045 | 2.114 | 2.129 | 100.7% |
| C046 | 2.123 | 2.141 | 100.9% |
| C047 | 2.186 | 2.187 | 100.1% |
| C048 | 2.149 | 2.143 | 99.7% |
| C049 | 2.154 | 2.148 | 99.7% |
| C050 | 2.165 | 2.164 | 100.0% |
| C051 | 2.151 | 2.158 | 100.3% |
| C052 | 2.153 | 2.158 | 100.2% |

| SN | Capacity BEFORE | Capacity AFTER | % of before |
|---|---|---|---|
| C094 | 2.127 | 2.137 | 100.5% |
| C095 | 2.154 | 2.151 | 99.9% |
| C096 | 2.149 | 2.148 | 99.9% |
| C097 | 2.151 | 2.160 | 100.4% |
| C098 | 2.140 | 2.151 | 100.5% |
| C099 | 2.158 | 2.157 | 100.0% |
| C100 | 2.101 | 2.124 | 101.1% |

| | Before | After |
|---|---|---|
| **Average** | **2.143** | **2.147** |

# 4. Lot Sample Tests

The objective of these tests is to verify that the safety features and characteristics of the new lot of flight Li-Ion cells are similar to the ones tested and certified for use on the Space Shuttle and International Space Station; the cells are cylindrical Li-Ion cells with a nominal voltage of 3.75 V and a capacity of 2200 mAh.

The tests have been designed to simulate possible power system anomalies leading to shorting, overcharging or overdischarging of flight cells that could occur prior to ejection of the PicoSat from the Shuttle or ISS. The requirement that the lot sample cells pass the following tests ensures that in the event of an on-orbit anomaly, flight hardware surrounding a flight cell(s) will not be damaged.

Lot sample testing was carried out on eight of the cells constituting the lot; the eight cells that were chosen had physical and electrochemical characteristics resembling the flight lot and are representative of potential flight cells. The vibrated cells underwent the lot sample tests described below. Current, voltage, and temperature versus time and the capacities (wherever applicable) was documented. Tests were carried out in the order shown to minimize the number of cells used for lot sample testing.

The results and observations confirmed the existing database on the abuse tolerance characteristics of the cells. Necessary precautions were taken during all phases of testing.

If any single cell had failed the criteria imposed for the lot sample testing, the whole lot would have been rejected.

## 4.1 Vibration Test

Eight fully charged cells were vibrated using the following spectrum for 15 min in each of the x, y, and z axes.

| Frequency (Hz) | Level |
|---|---|
| 20–80 | +3 dB/octave |
| 80–350 | 0.1 $g^2$/Hz |
| 350–2000 | –3 dB/octave |

Each cell's OCV was measured following vibration, and then was subjected to a discharge/charge/discharge to confirm functionality. The pass criteria are: the difference in OCV of the cells before and after vibration was within ±0.5%; the capacity obtained on the second discharge was greater than 95% of the capacity obtained in the second discharge test of Subsection 3.3 of the test plan for that particular cell.

The cells passed the OCV and capacity criteria. Results are shown in Table 6.

Table 6. Moli-Energy Li-Ion Cell Performance Before and After Vibration Test

| SN | OCV (V) BEFORE | OCV (V) AFTER | % change | Capacity BEFORE | Capacity AFTER | % of before |
|---|---|---|---|---|---|---|
| C022 | 4.161 | 4.160 | -0.02% | 2.142 | 2.085 | 97.33% |
| C011 | 4.161 | 4.160 | -0.02% | 2.147 | 2.086 | 97.17% |
| C012 | 4.160 | 4.159 | -0.02% | 2.130 | 2.082 | 97.73% |
| C014 | 4.161 | 4.160 | -0.02% | 2.134 | 2.077 | 97.34% |
| C021 | 4.161 | 4.160 | -0.02% | 2.102 | 2.055 | 97.80% |
| C025 | 4.161 | 4.160 | -0.02% | 2.136 | 2.081 | 97.43% |
| C026 | 4.162 | 4.161 | -0.02% | 2.145 | 2.087 | 97.29% |
| C031 | 4.161 | 4.160 | -0.02% | 2.128 | 2.074 | 97.43% |

## 4.2 Cell Safety Mechanism Testing

Two cells were used for each of the safety mechanism tests.

### 4.2.1 Short Circuit

Cells were charged individually with a 1 C (2 A) current to 4.2 V and held at constant voltage until the current fell to 20 mA. Each cell was subjected to a short circuit of less than 0.05 ohms. External temperature, current, and voltage of the cells were recorded during the tests. A positive temperature coefficient (PTC) device acts as a resettable fuse, and is expected to be activated within a few seconds on the application of a short circuit.

When the PTC was activated, the source of the short circuit was removed. If the PTC was not activated within a few seconds, cell temperature decrease was verified before removing the source of the short circuit. After a wait period of at least one hour, two charge/discharge cycles were performed. Charge/discharge curves displaying current and voltage as a function of time were plotted. There was no significant temperature change during cycling.

Cells C014 and C022 underwent short-circuit testing. Results are shown in Figure 1. Upon examination of each cell's respective current curve, it is apparent that both cells displayed activation of the PTC device within seconds of the short circuit. Note the abrupt change in the cells' current slope. The drop in current below about 60 A is due to an increase in impedance within the cell, caused by the activation of the cell's PTC device. Cells C014 and C022 passed the short-circuit testing. Shown in Figure 2 is a post-short-circuit discharge capacity curve comparison to baseline discharge capacity taken after the qualification-level vibration testing. The capacity curves of both cells overlap very closely in the comparison figure; they may be difficult to discern at multiple points. A zoomed plot of the end-of-discharge capacities is inset in the same figure.

### 4.2.2 Cell Overdischarge

The cells allotted for this test were charged with a 1 C (2 A) current to 4.2 V, and held at constant voltage until the current fell to 20 mA. Cells were then discharged at a 1 C (2 A) rate to 0.0 V; the discharge was continued to 150% of original capacity (3.0 Ah) using the same current. Two standard charge/discharge cycles were then attempted.

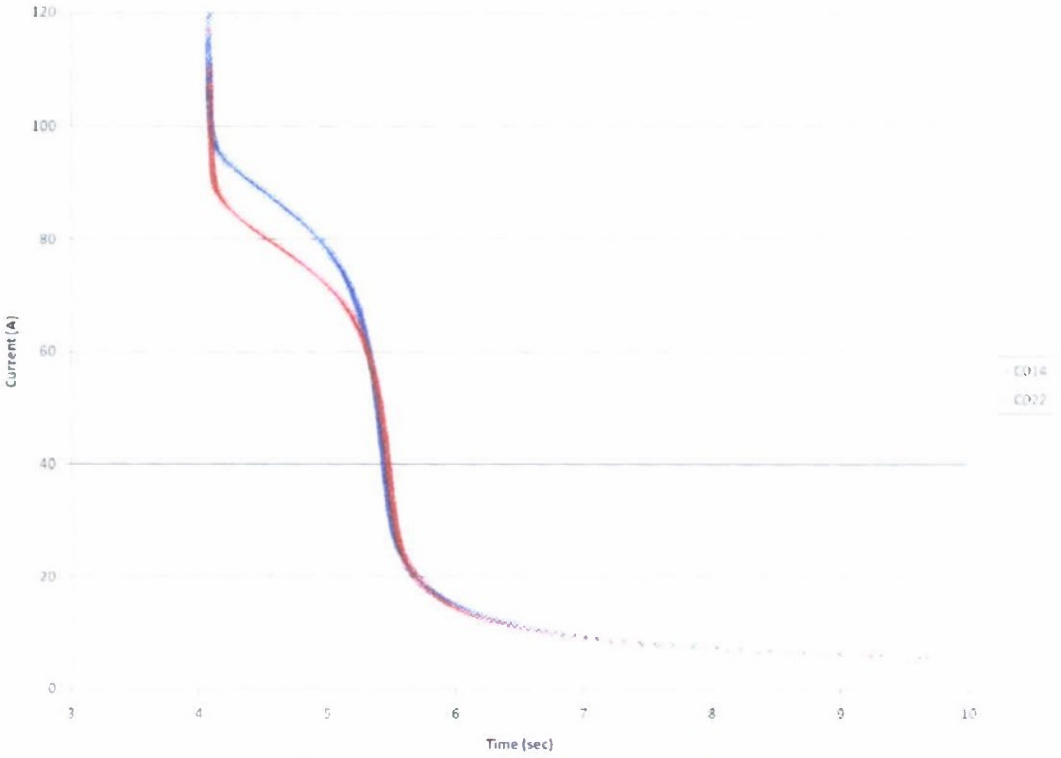


Figure 1. Cell current characteristics during short circuit.

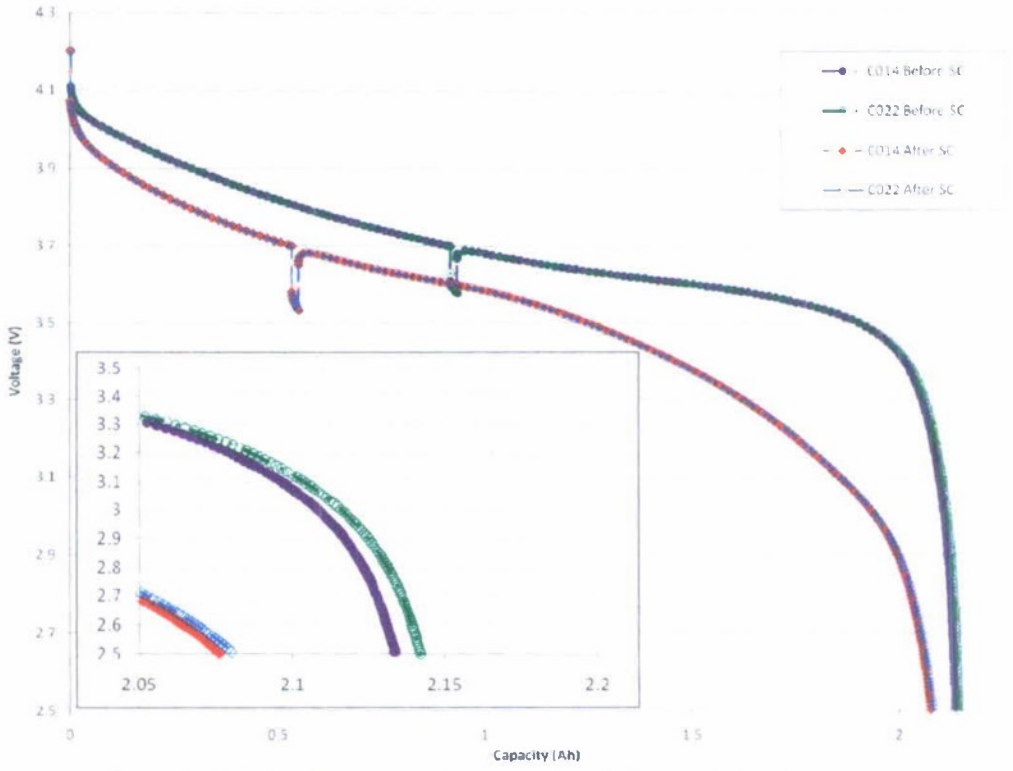


Figure 2. Cell discharge capacity comparison before and after short circuit.

Cells C012 and C026 underwent the overdischarge test. Although the cells displayed increases in temperature during the overdischarge, cell rupture, fire, or explosion did not occur. The cells did not perform during the follow-up charge/discharge cycles; this condition was not a failure criteria. The cells passed the overdischarge test.

Cell discharge voltages are shown in Figure 3. Note the region where the cells discharged below 0.0 V.

### 4.2.3 Cell Overcharge

The cells were charged at a 1 C (2 A) rate to 4.2 V until the current fell below 50 mA, and then over-charged at a 1 C (2 A) rate until the current interrupt device (CID) was activated. The overcharge voltage target was set for 10 V to allow sufficient headroom for the CID to activate. The CID is expected to activate near 5.0 V after a period of internal cell pressure buildup due to overcharge conditions.

Cells C011 and C021 underwent the overcharge test. Cell temperatures were monitored. Cell C011 displayed a temperature change from 22°C to 65°C. Cell C021 displayed a temperature change from 21°C to 55°C. Both cells displayed activation of their CID, the point at which the cells went open cir cuit. Monitored cell voltage maximums were near 5.0 V at the time when their CID activated. The cell characteristics of C021 are shown in Figure 4; CID activation is apparent at the point at which the voltage curve goes abruptly off scale, and the current curve drops to zero.

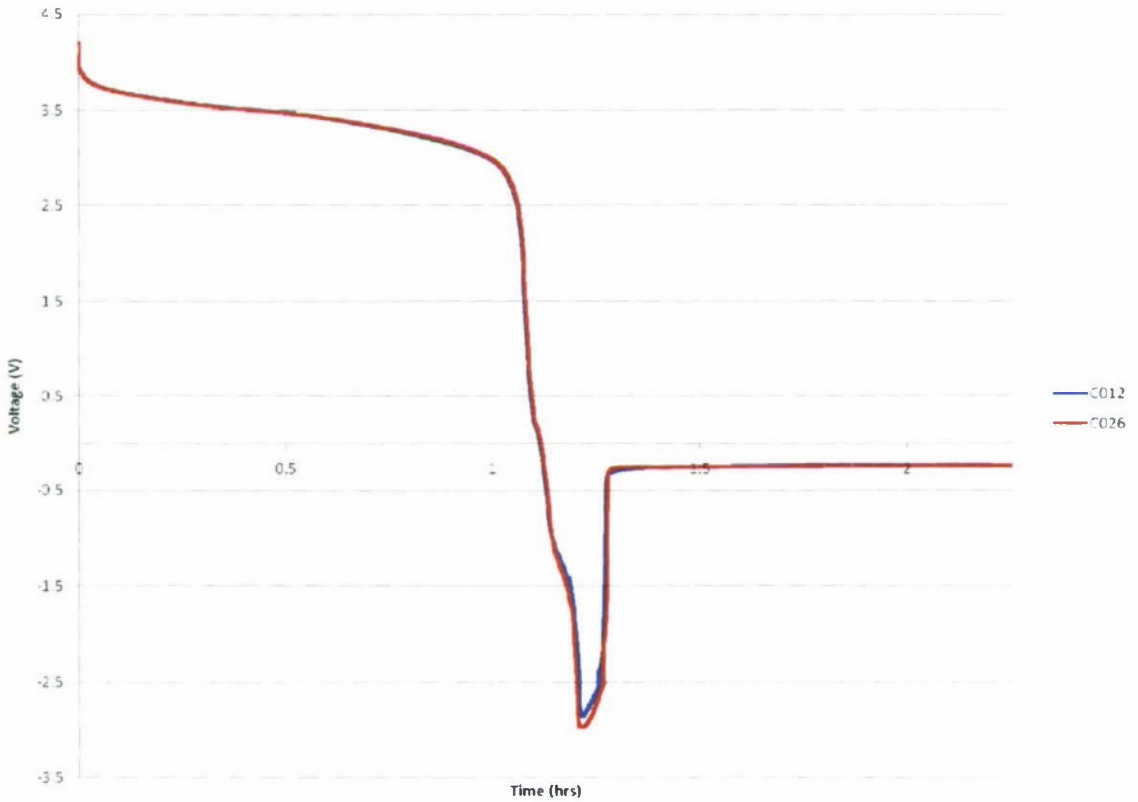


Figure 3. Cell overdischarge voltage characteristics.

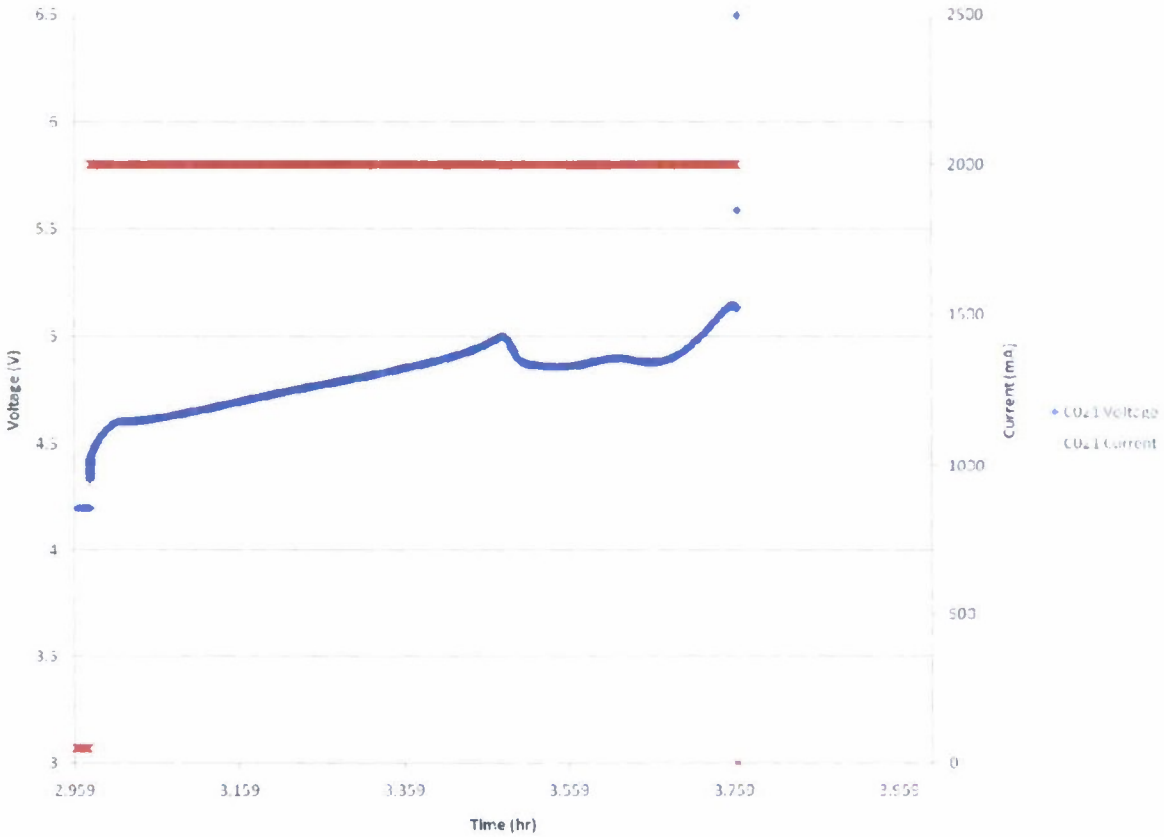


Figure 4. Cell C021 overcharge voltage characteristics.

It should be noted that the test was run incorrectly on cell C011. C011 was allowed to charge to 4.2 V until the current fell below 20 mA before being subjected to overcharge conditions. The overcharge test was also paused briefly before it resumed. The external cell temperature reached near 65°C, about 10°C higher than cell C021. Despite the incorrect test procedure, the cell's CID still activated.

Due to incorrect testing of cell C011, two additional cells were tested to ensure reproducibility of the results. Cells C025 and C031 also underwent the overcharge test. Cell C025 displayed a temperature change from 24°C to 48°C. Cell C031 displayed a temperature change from 22°C to 72°C. Both cells displayed activation of their CID, apparent by examining the point at which the voltage curve goes abruptly off scale, and the current curve drops to zero, visible in Figures 5 and 6.

No cell rupture, fire, or explosion occurred in any of the cells, including the incorrectly tested cell. The cells passed the overcharge test.

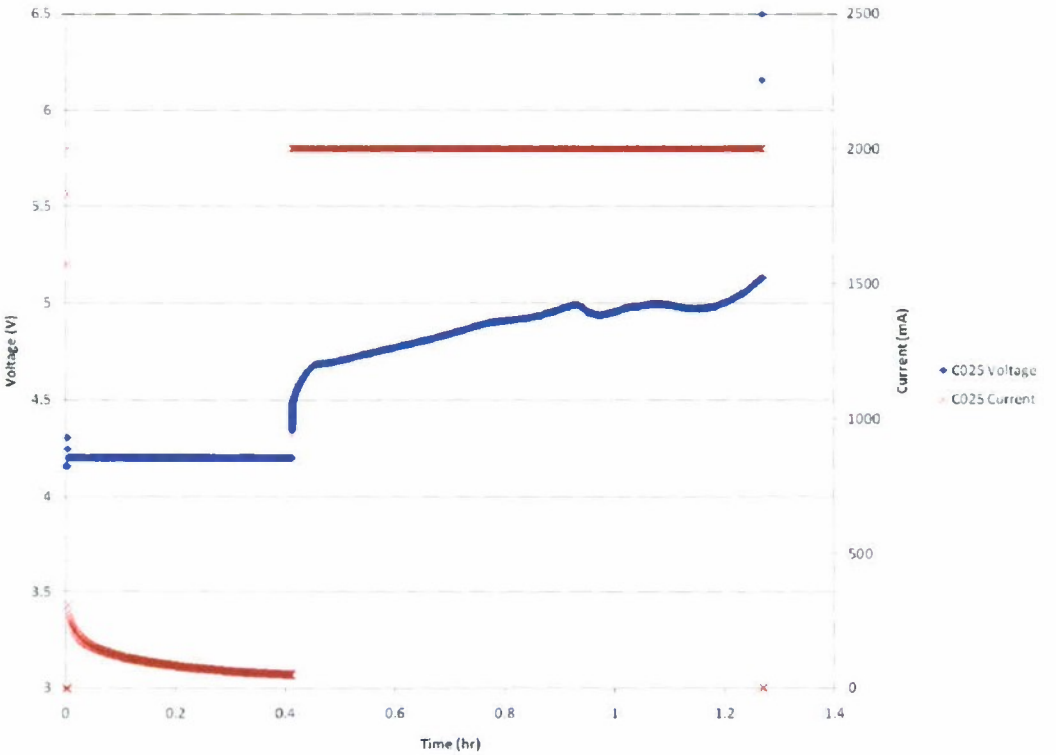


Figure 5. Cell C025 overcharge voltage characteristics.

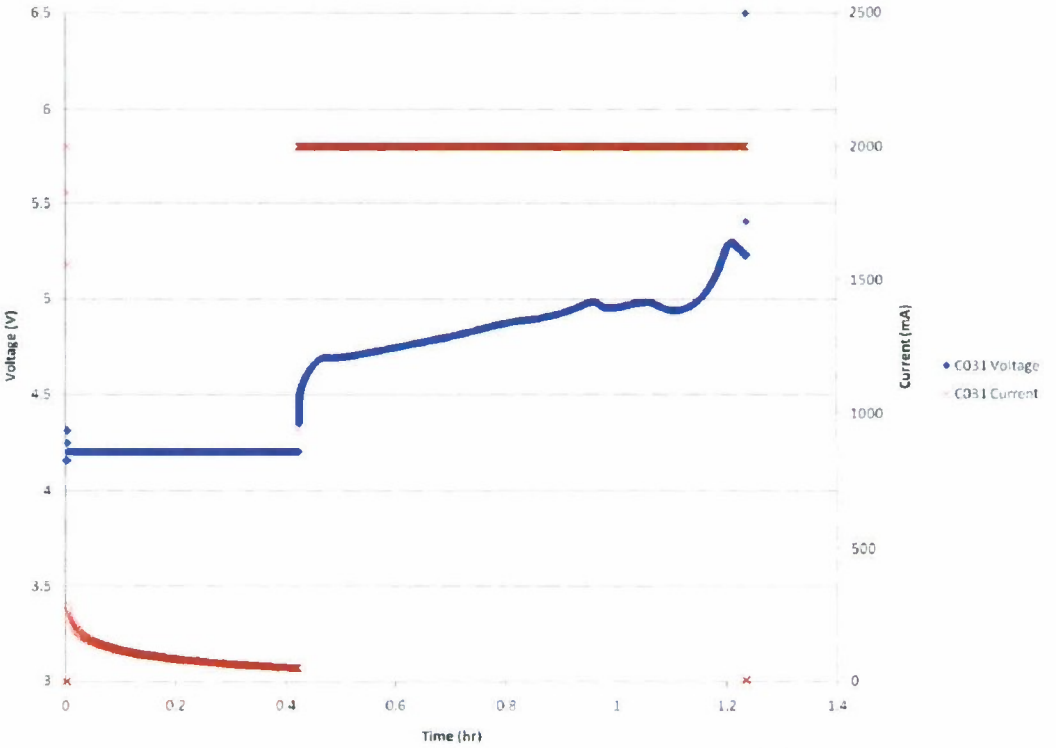


Figure 6. Cell C031 overcharge voltage characteristics.

## 5. Screening of Flight Cells

Screening of flight cells was completed following lot sample testing. Screening consisted of charging the cells to 4.2 V and holding at constant voltage until current fell below 20 mA, and was followed by a separate vibration test and charge/discharge cycles.

Vibration testing was performed using the spectrum below for one minute in each of the x, y, and z axes.

| Frequency | Level |
|---|---|
| 20–80 | +3 dB/octave |
| 80–350 | 0.067 $g^2$/Hz |
| 350–2000 | –3 dB/octave |

OCV measurements were taken before and after vibration. Charge/discharge cycles were also performed. OCVs before and after vibration were within ±0.5%, and capacity was greater than 95% of the capacity obtained during initial characterization. The cells passed the flight screening tests. Results are shown in Table 7.

Table 7. Moli-Energy Li-Ion Cell Flight Screening Vibration Test Performance Summary

| SN | OCV (V) BEFORE | OCV (V) AFTER | % change | Capacity BEFORE | Capacity AFTER | % of before |
|---|---|---|---|---|---|---|
| C001 | 4.181 | 4.171 | -0.24% | 2.129 | 2.107 | 98.95% |
| C002 | 4.181 | 4.171 | -0.23% | 2.154 | 2.139 | 99.29% |
| C003 | 4.181 | 4.172 | -0.23% | 2.132 | 2.104 | 98.68% |
| C004 | 4.181 | 4.171 | -0.23% | 2.113 | 2.098 | 99.27% |
| C005 | 4.181 | 4.171 | -0.23% | 2.135 | 2.119 | 99.26% |
| C006 | 4.182 | 4.172 | -0.24% | 2.133 | 2.115 | 99.16% |
| C007 | 4.181 | 4.171 | -0.24% | 2.151 | 2.129 | 99.01% |
| C008 | 4.181 | 4.171 | -0.24% | 2.125 | 2.107 | 99.17% |
| C010 | 4.181 | 4.172 | -0.22% | 2.137 | 2.112 | 98.83% |
| C013 | 4.182 | 4.173 | -0.21% | 2.146 | 2.121 | 98.84% |
| C015 | 4.181 | 4.171 | -0.23% | 2.126 | 2.104 | 98.97% |
| C016 | 4.181 | 4.172 | -0.22% | 2.121 | 2.1 | 98.97% |
| C017 | 4.181 | 4.171 | -0.23% | 2.143 | 2.118 | 98.80% |
| C018 | 4.182 | 4.172 | -0.23% | 2.139 | 2.114 | 98.87% |
| C019 | 4.179 | 4.171 | -0.20% | 2.142 | 2.119 | 98.92% |
| C020 | 4.18 | 4.172 | -0.18% | 2.118 | 2.097 | 99.00% |
| C024 | 4.179 | 4.172 | -0.17% | 2.117 | 2.089 | 98.67% |
| C027 | 4.179 | 4.171 | -0.18% | 2.138 | 2.116 | 98.97% |
| C028 | 4.179 | 4.172 | -0.17% | 2.108 | 2.092 | 99.24% |
| C029 | 4.178 | 4.17 | -0.19% | 2.151 | 2.134 | 99.21% |
| C030 | 4.179 | 4.171 | -0.19% | 2.116 | 2.103 | 99.40% |
| C032 | 4.179 | 4.171 | -0.20% | 2.145 | 2.122 | 98.90% |
| C033 | 4.179 | 4.171 | -0.19% | 2.158 | 2.136 | 98.95% |
| C034 | 4.179 | 4.172 | -0.18% | 2.126 | 2.103 | 98.92% |
| C035 | 4.181 | 4.172 | -0.22% | 2.148 | 2.119 | 98.65% |

| SN | OCV (V) BEFORE | OCV (V) AFTER | % change | Capacity BEFORE | Capacity AFTER | % of before |
|---|---|---|---|---|---|---|
| C036 | 4.179 | 4.171 | -0.19% | 2.166 | 2.132 | 98.42% |
| C037 | 4.179 | 4.172 | -0.16% | 2.142 | 2.111 | 98.56% |
| C038 | 4.179 | 4.173 | -0.16% | 2.163 | 2.114 | 97.71% |
| C039 | 4.18 | 4.173 | -0.17% | 2.149 | 2.104 | 97.88% |
| C040 | 4.179 | 4.171 | -0.18% | 2.161 | 2.112 | 97.72% |
| C041 | 4.178 | 4.171 | -0.18% | 2.134 | 2.109 | 98.84% |
| C042 | 4.179 | 4.172 | -0.17% | 2.156 | 2.113 | 98.04% |
| C043 | 4.179 | 4.172 | -0.18% | 2.13 | 2.104 | 98.77% |
| C044 | 4.179 | 4.17 | -0.22% | 2.139 | 2.108 | 98.55% |
| C045 | 4.18 | 4.173 | -0.16% | 2.114 | 2.093 | 99.00% |
| C046 | 4.179 | 4.171 | -0.19% | 2.123 | 2.1 | 98.92% |
| C047 | 4.149 | 4.144 | -0.11% | 2.186 | 2.158 | 98.70% |
| C048 | 4.18 | 4.172 | -0.18% | 2.149 | 2.104 | 97.90% |
| C049 | 4.179 | 4.172 | -0.17% | 2.154 | 2.114 | 98.14% |
| C050 | 4.178 | 4.171 | -0.17% | 2.165 | 2.131 | 98.42% |
| C051 | 4.178 | 4.171 | -0.18% | 2.151 | 2.124 | 98.77% |
| C052 | 4.178 | 4.172 | -0.13% | 2.153 | 2.122 | 98.53% |
| C053 | 4.178 | 4.171 | -0.17% | 2.132 | 2.097 | 98.35% |
| C054 | 4.18 | 4.174 | -0.13% | 2.182 | 2.137 | 97.95% |
| C055 | 4.177 | 4.17 | -0.17% | 2.157 | 2.118 | 98.20% |
| C056 | 4.177 | 4.171 | -0.15% | 2.151 | 2.107 | 97.95% |
| C057 | 4.178 | 4.172 | -0.16% | 2.161 | 2.12 | 98.10% |
| C058 | 4.177 | 4.171 | -0.16% | 2.161 | 2.125 | 98.32% |
| C059 | 4.177 | 4.17 | -0.16% | 2.143 | 2.114 | 98.68% |
| C060 | 4.177 | 4.171 | -0.15% | 2.12 | 2.092 | 98.66% |
| C061 | 4.15 | 4.145 | -0.12% | 2.162 | 2.127 | 98.37% |
| C062 | 4.177 | 4.17 | -0.16% | 2.164 | 2.132 | 98.52% |
| C063 | 4.178 | 4.172 | -0.17% | 2.162 | 2.139 | 98.94% |
| C064 | 4.178 | 4.172 | -0.15% | 2.148 | 2.117 | 98.57% |
| C065 | 4.179 | 4.174 | -0.12% | 2.161 | 2.131 | 98.64% |
| C066 | 4.179 | 4.173 | -0.15% | 2.135 | 2.11 | 98.82% |
| C067 | 4.177 | 4.171 | -0.15% | 2.156 | 2.117 | 98.19% |
| C068 | 4.178 | 4.173 | -0.13% | 2.147 | 2.106 | 98.13% |
| C069 | 4.179 | 4.173 | -0.14% | 2.126 | 2.088 | 98.19% |
| C070 | 4.178 | 4.172 | -0.15% | 2.133 | 2.097 | 98.32% |
| C071 | 4.177 | 4.171 | -0.15% | 2.168 | 2.134 | 98.42% |
| C072 | 4.177 | 4.171 | -0.15% | 2.134 | 2.117 | 99.18% |
| C073 | 4.177 | 4.171 | -0.14% | 2.109 | 2.095 | 99.32% |
| C074 | 4.178 | 4.171 | -0.16% | 2.125 | 2.099 | 98.74% |
| C075 | 4.177 | 4.17 | -0.16% | 2.158 | 2.119 | 98.20% |
| C076 | 4.177 | 4.17 | -0.15% | 2.148 | 2.122 | 98.79% |
| C077 | 4.177 | 4.171 | -0.15% | 2.145 | 2.12 | 98.84% |
| C078 | 4.177 | 4.171 | -0.15% | 2.151 | 2.106 | 97.92% |
| C079 | 4.177 | 4.172 | -0.12% | 2.153 | 2.127 | 98.80% |
| C080 | 4.177 | 4.171 | -0.16% | 2.159 | 2.127 | 98.52% |
| C081 | 4.177 | 4.171 | -0.15% | 2.138 | 2.11 | 98.67% |
| C082 | 4.178 | 4.173 | -0.12% | 2.161 | 2.122 | 98.21% |
| C083 | 4.177 | 4.171 | -0.15% | 2.138 | 2.105 | 98.46% |
| C084 | 4.176 | 4.17 | -0.15% | 2.137 | 2.117 | 99.03% |
| C085 | 4.177 | 4.17 | -0.15% | 2.169 | 2.141 | 98.71% |
| C086 | 4.176 | 4.17 | -0.16% | 2.153 | 2.121 | 98.52% |
| C087 | 4.178 | 4.171 | -0.15% | 2.141 | 2.114 | 98.74% |

| SN | OCV (V) BEFORE | OCV (V) AFTER | % change | Capacity BEFORE | Capacity AFTER | % of before |
|---|---|---|---|---|---|---|
| C088 | 4.177 | 4.171 | -0.14% | 2.158 | 2.123 | 98.36% |
| C089 | 4.177 | 4.172 | -0.13% | 2.171 | 2.132 | 98.21% |
| C090 | 4.178 | 4.172 | -0.14% | 2.141 | 2.111 | 98.60% |
| C091 | 4.177 | 4.172 | -0.14% | 2.158 | 2.121 | 98.32% |
| C092 | 4.176 | 4.17 | -0.15% | 2.154 | 2.122 | 98.55% |
| C093 | 4.177 | 4.171 | -0.14% | 2.144 | 2.107 | 98.28% |
| C094 | 4.179 | 4.173 | -0.13% | 2.127 | 2.097 | 98.59% |
| C095 | 4.177 | 4.171 | -0.15% | 2.154 | 2.114 | 98.14% |
| C096 | 4.177 | 4.17 | -0.16% | 2.149 | 2.111 | 98.23% |
| C097 | 4.179 | 4.172 | -0.18% | 2.151 | 2.13 | 99.04% |
| C098 | 4.179 | 4.173 | -0.15% | 2.14 | 2.116 | 98.85% |
| C099 | 4.177 | 4.17 | -0.16% | 2.158 | 2.128 | 98.59% |
| C100 | 4.178 | 4.171 | -0.16% | 2.101 | 2.078 | 98.91% |
| Average | 4.178 | 4.171 | -0.17% | 2.144 | 2.115 | 98.63% |

## 6. Summary

This report contains results from the sample testing as well as the flight screening required for flight certification of a new lot of Moli-Energy Li-Ion 2200-mAh, 3.75-V cells to be used for the PSSC Testbed follow-up mission. Lot characterization testing began upon receipt of a new lot of Moli-Energy ICR-18650H cells in March 2009. The lot was screened for flight certification according to NASA standards. Cell-level characterization of all flight cells from the lot and safety mechanism testing on a subset of cells was performed. The safety mechanism testing consisted of external short circuit, overcharge, and overdischarge tests; the cells passed all testing.

## Reference

i. Halpine, J. S.; Liu, S.; and J. Lee, "Li-Ion Cell Specification for Lot Testing and Flight Screening Testing Results," Aerospace Report No. TOR-2009(8511)-10. 20 October 2009.